ANTI-MALARIAL WORK IN MACEDONIA

WILLOUGHBY & CASSIDY


0
1
2
3
4
5
6
7
8
9
10

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AMONG BRITISH TROOPS

BY

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136 GOWER STREET, LONDON, W.C. 1
1918

PREFACE

At the close of the second malaria season during which British troops have occupied part of Macedonia we thought it might be interesting to describe some of the aspects of the anti-malaria work carried on in and near one large section of the front.

The continued prevalence of so much malaria, in spite of the persistent efforts of the R.A.M.C. and others, is a matter for regret. This regret is, however, mitigated by the knowledge that the work resulted in an improvement in 1917 as compared with 1916.

The account in the following pages is not intended as a scientific work, but is simply a record of personal practical experience which may possibly, we hope, be of use to others called upon to do anti-malaria duties in this difficult country.

To make the account more complete for those with little previous knowledge of malaria, we have added a brief description of the mosquito and its connection with the disease.

W. G. W.
L. C.

November, 1917.

CONTENTS

LIST OF ILLUSTRATIONS

PLATES.

ANTI-MALARIA WORK IN MACEDONIA

CHAPTER I

MALARIA AND THE MOSQUITO

MALARIA is due to a microscopic organism whose life-history is only complete when it has existed in the human being and in a mosquito. While apparently any human being is a useful medium for this organism, it is selective as regards its definitive host, the mosquito, and only thrives in certain species of these insects.

At least three varieties of the organism cause malaria. *Plasmodium vivax* causes benign tertian, *P. malariæ* causes quartan, and *P. falciparum* causes malignant tertian malaria.

The mosquito hosts of the plasmodia are anophelines. There are various varieties of anophelines, some of which act as hosts and some do not. The chief malaria transmitting species in one country may not be so in another country.

In Macedonia the chief anophelines we have found have been *A. maculipennis* and *A. superpictus*.

A. pseudopictus and *A. bifurcatus*, and possibly others, also occur.

The aim of this work being to describe practical prevention of malaria, we do not propose to discuss the important question as to how far any particular species is concerned with any particular form of illness. This matter is being investigated by scientists.

From the association of certain forms of malaria with the seasons and places of finding certain species of anophelines particularly prevalent, it is likely that *A. superpictus* and *A. pseudopictus* are responsible especially for malaria of a malignant type, but practically there need be no local selective process in the work of destroying mosquitoes, even if all those engaged in the work had the requisite knowledge.

The complete extirpation of one variety of mosquito in any locality will involve that of the others also, since their habits and mode of development are to this extent sufficiently alike. In any event, all mosquitoes are nuisances, they may be carriers of other diseases besides malaria, and should therefore be destroyed.

The course, or cycle, of infection is briefly as follows: An anopheline mosquito infected with the plasmodium, in biting, transmits the organisms from her salivary glands to the blood-circulation of the human victim. After the lapse of about twelve days these organisms have so multiplied and have so acted in connection with the red blood-cells that the symptoms of malaria appear.

The individual thus bitten becomes later on a carrier of organisms unless he has had very thorough treatment, a chronic case being more dangerous in this respect than an acute case.

When this infected person is again bitten by a mosquito requiring blood for the development of her eggs, she at the same time sucks in with the blood a number of the organisms. These are sometimes altered, in that they have taken on a sexual character, and in the stomach of the mosquito exercise their sexual functions.

The resulting progeny eventually find their way from the stomach to the salivary glands of the insect, and are in readiness for injection into another human victim, and the cycle is complete.

The course of events in the mosquito itself lasts from ten to twelve days, and a temperature of at least about 60° F. is said to be requisite for the process.

Only the female mosquito bites man; she must have blood for the development of her maternal activities. She can take over a cubic millimetre of blood at a time, and we are informed that this quantity of blood from a favourable human subject may contain thousands of organisms. The male insect is apparently a vegetarian, and harmless except for the breeding of more females.

The cycle of infection briefly described above, which is often complicated by repeated biting, is the only mode of spread of malaria scientifically demonstrated at present, and gives the clue to the necessary basis for preventive action.

It indicates that in addition to the plasmodium itself, which cannot be dealt with apart from the mosquito or the blood of the human victim, there are three principal essentials for a case of malaria. These are, the infected person from whom the mosquito originally obtains the plasmodium, the mosquito of the particular species by which this can be transmitted, and thirdly the victim.

In Macedonia infected persons abound among the natives, and now also among our own men. The transmitting species of mosquito also abound; our troops are the victims.

In our account of preventive methods we therefore discuss the destruction of the mosquito in all stages of its life-history and the protection of the troops, the potential victims. As regards the infected individual who starts the cycle, much can also be done to render his infected state a lesser danger to the community.

In the case of the infected natives, especially children, isolation and removal from the neighbourhood of our men is practicable, and has been carried out to a great extent at the front. In the case of our own infected men who cannot be removed from the district, the points to be aimed at are their cure by very thorough quinine treatment, and their thorough protection from further mosquito bites, so that the infection cannot be passed on to others.

Another method of defence that requires attention is that of rendering the infected bite harmless to the victim by the use of prophylactic drugs, especially

quinine. Though important, this is obviously but a subsidiary resource, to be employed when other methods are not sufficiently practicable to be efficient.

A working knowledge of the course of development of the mosquito, its life and habits, is necessary before the various means of prevention can be put into satisfactory operation.

The common species of mosquitoes in Macedonia are anophelines, various varieties of which can transmit the malaria plasmodium, and culicines, which are apparently harmless as regards malaria.

The life-history of the anopheline is briefly this: The adult insect lays her eggs on the surface of water; after about two to three days the eggs hatch into larvæ, which in their turn become pupæ in from about seven to ten days. The insect emerges from the pupal stage after another two to three days. The time of the complete cycle is therefore from about eleven to sixteen days. It is important to bear these times in mind in planning destructive processes.

The larval stage is very important in anti-malaria work, for it is that in which destruction can be most easily carried out. Larvæ are easily seen, being from about one-quarter to half an inch in length. They constantly come to the surface of the water, but can remain below for some time, so that search should not be abandoned too quickly. Sometimes, when they are not at once seen, a gentle movement of the weed or other contents of the water will cause them to show themselves.

The commonest anopheline larva in our area was a small, very dark one with a light neck, the larva of *A. superpictus*. Weedy streams were a favourite haunt of this variety. The larger, lighter larva of *A. maculipennis* was also common, especially early in the summer. Occasionally other species were found. The *A. pseudopictus* found in the marshy borders of a lake was apparently associated with the severe type of malaria in the vicinity.

The principal breeding-time is from mid-June to the end of September, but larvæ have been found even in the winter months. Mid-September seems to be the culminating point of the breeding; most cases of malaria in our district in any one week in 1917 were notified in the beginning of October.

The anopheline larva is said to prefer shady, clear, and stagnant water, with weeds in it. This is so, especially as regards weeds, but we have found these larvæ in any and every variety of water in Macedonia.

The anopheline mosquito bites, as a rule, in the twilight and at night. We have, however, seen them biting in the daytime in darkened places, such as "dug-outs." They remain in dark places and in undergrowth during the day. Anophelines have been found in large numbers in the "day-shelters," as well as in the quite dark "dug-outs"; they may be seen on the walls and ceilings. They are found among clothes and bedding, between the layers of double tents, and also in shelters such as helmets. Heavy rain drives them into buildings in large quantities.

The anopheline bite is less irritating than that of culex.

Mosquitoes strongly object to wind, and are found chiefly to leeward of their breeding-places. They travel much farther than the half-mile which has been sometimes mentioned as their limit of flight.

A temperature of 60° F. is said to be necessary for the changes in the plasmodium inside the mosquito, though winter cases seem to show there may be exceptions.

The anopheline mosquito hibernates during the winter months in "dug-outs" and dark parts of buildings. It is said that she can retain during this time her infecting organisms, ready for action in the following spring and summer. In Macedonia, however, there is abundant material for fresh infection of anophelines all the year round.

The following are some practical points in distinguishing the anopheline or malaria mosquito from the culicine:

(*a*) THE INSECT.—The anopheline alights on, and rests on, a surface with its body at an angle to it; the common forms in Macedonia have spotted wings; the female's palp is about as long as her proboscis.

The culicine's body is nearly parallel to the surface on which it alights, its wings are clear, and the palps quite short.

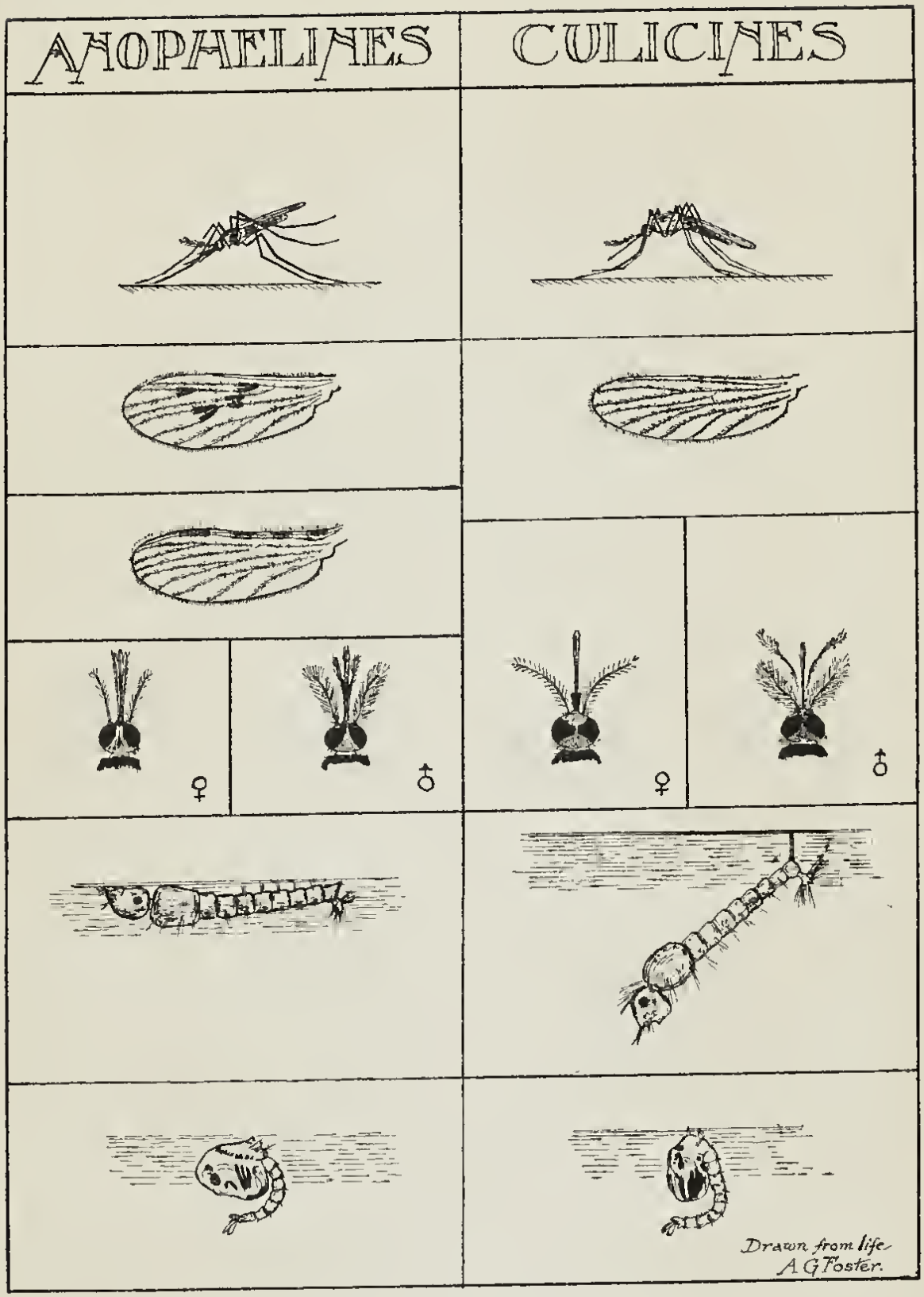
(*b*) THE LARVA.—The anopheline, when at the surface, lies parallel to it on the water; its head is small compared with the thorax, and it projects no siphon.

The culicine larva lies under the water at an angle of about 45° with the surface, through which the siphon projects; the head is large and the lateral hairs plain.

(*c*) THE PUPA.—The siphon tubes of the anopheline are broad and situate at the middle of the head end of the pupa; in the culicine they are longer, not so broad, and situate at the back of the head.

(*d*) THE EGGS.—In anophelines the eggs are in sets of about 100, in irregular patterns; in culicines the eggs are about 250 in number, set vertically in rafts of about one-fifth of an inch in longest diameter.

Rapid differentiation is only practically easy in the larva and insect stages, but there is for most anti-malaria workers among the troops no need to discriminate, but to kill any and every mosquito possible in any stage of its existence.



ILLUSTRATIONS COMPARING ANOPHELINES AND CULICINES.

(*Magnified.*)

To face page 18

CHAPTER II

PREVALENCE OF MALARIA

As the object of this work is to give an account of anti-malaria work in a large part of the area in Macedonia occupied by our troops, it would be more complete if it included statistics showing the extent to which the disease has prevailed.

On the other hand, under present circumstances, obviously, no figures can be given which might indicate numbers of troops. We are confined, therefore, to mentioning certain of the broad facts within our experience. It is common knowledge that the troops of all nations operating in Macedonia suffer considerably from malaria. Statistics on the subject will no doubt be available at the end of the war.

The smallness, relatively, of the casualty lists that appear in the Press in connection with the Salonika Force has apparently sometimes given the uninformed the mistaken idea that the troops on this front have had an easy time. In proportion they have had a considerable share of fighting, but the casualty figures are dwarfed by those of sickness due to malaria.

There are few men who would not gladly exchange out of malarious Macedonia. Front-line troops have

not only fighting to do, but are continuously exposed at night, and sometimes by day also, to the bites of thousands of small enemies which cannot be adequately dealt with because their breeding-grounds are in " no man's land " between the opposing forces, or because of other difficulties indicated later on.

The malaria following the bites disables men for a time as surely as a wound (without the compensating gold stripe on the sleeve); recurrences are common, and a long and tedious convalescence often ensues. In this way a large proportion of the troops have to " carry on," knowing that in the unavoidable absence of complete precautions, though the bullet may miss its billet, the mosquito will probably not do so.

Behind the front line anophelines are still so omnipresent that, notwithstanding unceasing anti-malarial work, the troops are everywhere exposed nightly to the chances of infection, though much less so than at the front (except in certain areas). A few districts of the occupied portion of the country are almost free from infected mosquitoes, but in most parts they abound, and in none is there absolute immunity.

The circumstances in 1917 were more difficult to contend with than in 1916 in this important respect, that, owing to the cases of the previous year, infected " carriers " were to be found in almost all units.

In spite of this, there has been an appreciable decrease of malaria among troops in the area to which this book refers, and probably elsewhere also. In September a very satisfactory percentage of men was

saved for active service as compared with September, 1916. When the great increase of material for infecting mosquitoes is considered, together with the fact that the same partly untreatable malarious districts had to be still occupied, it will be understood that a great increase of malaria might have been expected, rather than a decrease, had not the continuous anti-malarial work had a good measure of success.

The curve of weekly notifications of the cases of malaria removed to the base hospitals was at its lowest in the beginning of January, and at its highest in the second week of October. Allowing a fortnight for the development of the disease, and a week's delay in notification and blood examinations, this points to a maximum biting season at mid-September.

Recurrences due to other causes than fresh infection by biting, probably do not affect the accuracy of this as a general proposition.

It is not possible to distinguish for statistical purposes between recurrences due to chills, heat, fatigue, or other similar causes, and recurrences due to renewed infection by biting.

When the curve was at its lowest, in January, in the region with which we are dealing, about 1 man in 1,000 weekly was evacuated to the base with malaria; at its height, early in October, the proportion was 1 in 30 or less. In addition, there were many cases not severe enough for evacuation beyond the area. Many of the cases were repeated recurrences in the same individual.

From January, the weekly number of cases rose steadily until the third week of May, when about 1 in 130 had to be evacuated. After this there was a slight remission. A sudden rise occurred towards the end of June, and continued through the first three weeks of July, when the figures reached 1 in about 55. This figure was not exceeded or even reached again until mid-September. After a slight fall then, the rise was sudden, and reached its maximum in the second week of October.

The rise in September and October was more acute than that of June and July.

It must be remembered that these figures include recurrences in the same individual, apply to one area solely, are those only of cases evacuated to the base, and probably average three weeks later than the times of the actual mosquito bites causing the attacks.

According to hospital records, about 15 per cent. of the cases in the winter, and about 50 per cent. of the summer cases, were "primary" malaria. It is probable that the percentage of recurrent cases was, however, much higher than 85 and 50 for winter and summer respectively. In the spring and autumn the percentages were intermediate.

Fortunately the mortality was very light indeed, and the men were mostly able to return to duty. Repeated recurrences, however, have their effect, in spite of the spirit of the men, which has remained excellent.

The splenic index (*i.e.*, percentage presence of

enlarged spleens as a result of malaria) of a large series of men working in a bad district and specially examined while still on duty, was as high as 19 per cent., and about 60 per cent. of these men had had definite attacks of malaria.

Some specially exposed units have had almost, if not absolutely, all their personnel infected at some time, and in a few cases a number as large as one-third of the strength of the unit has been evacuated to hospital within a month in the height of the malaria season.

This necessarily incomplete and superficial indication of the extent of prevalence of malaria in 1917, conveys possibly some idea of the size of the problem confronting the R.A.M.C. The forces in Macedonia have no need to be told that they are not out there for the benefit of their health.

CHAPTER III

NATURE OF THE COUNTRY

THE natural characteristics of the part of Macedonia occupied by British troops conduce to malaria. The country is mostly mountainous, with many separate hills of varying height in each range. The ravines and valleys are therefore very numerous, and contain in the aggregate an abundance of water. At the foot of the hills there are large plains through which the water has to find its way to lakes and to the sea. The number of ravines in both hills and plains is quite a feature of the district. They intersect in all directions the many semi-isolated hills, which rise to heights varying from about five to sixteen hundred feet above the plains. In the parts immediately beyond those occupied by our troops, the hills and ranges are occasionally very much higher.

In the ravines the watercourses are narrow, with frequent rocky pools. The water is overhung with vegetation. Though the current may be strong, there are weeds and many quiet off-shoots in which larvæ are found.

In the plains the large volume of water in winter

PLATE I.

A.

B.

VIEWS OF THE TWO LAKES DESCRIBED IN THE TEXT.

To face page 25.

and in sudden storms has worn very deep, and in places very wide, stream-beds. These stream-beds are only partially filled with water in the hot malaria months. There are then large pools and patches of stagnant water, generally full of weeds. The stream itself has often no very definite channel, but spreads over its wide bed, forming weedy shallows which, with the isolated ponds, offer an irresistible attraction to the mosquito for breeding purposes. Streams in a sandy bed often end abruptly and reappear lower down the channel, having run for varying distances under the surface. Depressions in the bed are filled with water, and form breeding-places.

The lakes in the district have, in places, large surrounding patches of marshy ground, overgrown with rushes and weeds, and containing here and there pools of open water. These marshes are so full of dense vegetation and are so water-logged that the mosquito has an ideal place in which to thrive, both in its insect and larva stages of existence. One of these marshes is many square kilometres in area, and a much-used road runs for some miles along its border. Military exigencies required that, in the summer of 1917, camps should be situated near this particular marsh. The men temporarily living in these camps, and those using the road at night, were particularly exposed to mosquito bites.

In the case of another large lake the border marsh is smaller, but adjoins a portion of the front line occupied by British troops.

There are other smaller areas of marshy ground which are not such difficult problems in anti-malarial work. These are sometimes caused by a spring rising on level ground, or by a stream ending blindly on a level without a natural outlet.

Ponds and pools abound, especially in ravines and beds of streams. In the latter the bottoms of the pools are often below the level of the remnant of water in the stream. Such incidents as removal of sand for road-making, or hoof-marks of horses and mules in the river-beds, cause pools to form, which quickly become breeding-places.

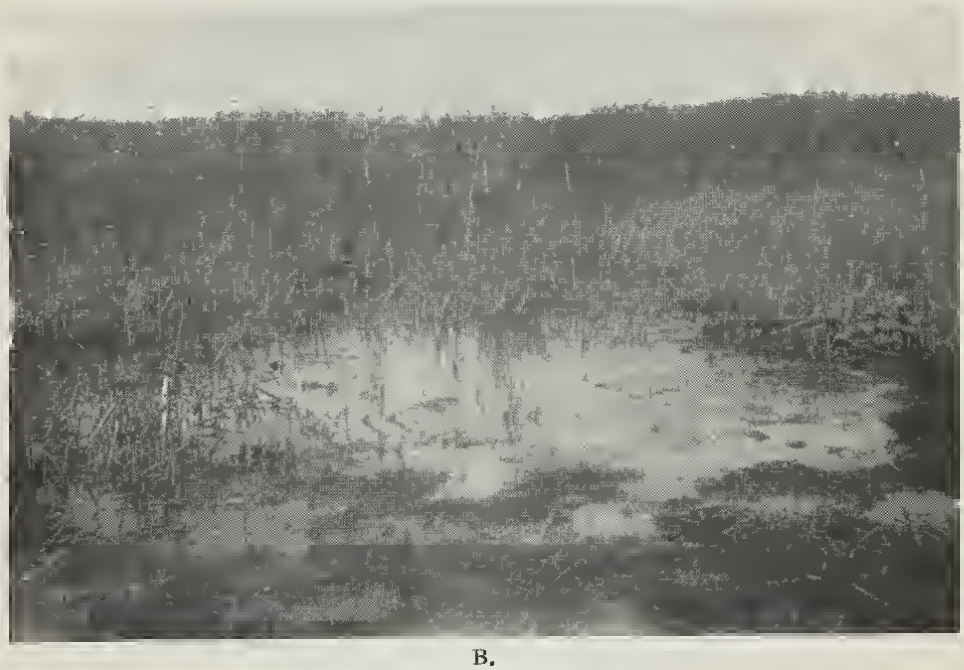
In the ravines of the hilly country rocky dams cause the formation of sheltered pools in which there may be a slight current which is not strong enough to prevent the hatching out of mosquitoes.

Springs are plentiful. Every village has at least one public fountain fed by a spring. Similar fountains are also found here and there at a distance from villages. The Turks were very good at providing water-supplies. In a fair number of fountains the flow is constant all the year round, and the unkempt waste forms semi-stagnant water-logged areas which are soon adopted for breeding purposes in the summer by the mosquito. Wells are less common, but there are many of them, and these also may become infested with larvæ.

The almost universal presence of all forms of natural accumulations of water in the district has its important uses, but from an anti-malarial point of view

PLATE II.

A.



B.

EXAMPLES OF THE MARSHY BORDERS OF THE LAKES.
ANOPHELINE LARVÆ ABUNDANT.

To face page 26.

necessitates much constant labour. To this has to be added the necessity for constant attention to the abundant collections of "accidental water" in such places as old tins, horse-troughs, tubs, and irrigation channels. Any form of water comes handy to the ubiquitous mosquito if the water is left without attention for a sufficient number of days.

VEGETATION.—The universally abundant vegetation along the banks of the streams and lakes is useful to the mosquito as a resting-place by day. Trees in most of our area are not common. The abundant long grass and rushes form very convenient shelters for insects of all kinds. In the hilly districts a small oak scrub, bracken, and dense brakes of undergrowth are found in and near the ravines. When a stream has to be channelled, especially in the plains, the overlapping undergrowth has first to be cut away. At times this was necessary before we could even see the water which required attention.

So great was the amount of long grass and other weeds in 1917, even apart from the neighbourhood of water, that wholesale "prairie fires" had to be organised on an extensive scale.

The wholesale destruction of villages in the various Balkan wars has done away with much of the artificially cultivated vegetation and favoured the growth of weeds.

Vegetation in the water itself flourishes. Rushes and water-grasses are common. A particularly ubiquitous and rapidly growing green water-weed, re-

sembling a loose piece of cotton-wool in consistency, and lying entirely in the water, enables larvæ to enjoy a comfortable existence even in a fairly fast-flowing stream. The larvæ of *A. superpictus* particularly flourished in such positions. If a stream-bed that has been canalised is not cleared of this weed in particular at regular intervals, the value of canalisation is to a very great extent lost.

CLIMATE.—The great heat of the Macedonian summer favours mosquito life. In July, August, and September, the average temperature is well up in the nineties in the shade. The nights remain warm, and the heat is a humid one. A shade temperature of 106·8° F. was recorded about 2 p.m., which is usually the hottest period, on one day in August. There were others of over 100° F. from time to time.

Rain during these three months was rare. The rain of large thunder-storms is useful in destroying mosquitoes and their larvæ, but resulting water requires attention and channelling requires repair.

THE INHABITANTS.—In addition to the ideal natural conditions for its existence, the mosquito has another advantage as a malaria transmitter in the state of the inhabitants. These, who are very mixed, and include Bulgars, Greeks, and Turks, must be practically all malaria "carriers." The number and extent of the village cemeteries bear eloquent testimony to the ravages caused by this disease. The survivors, especially the children, very often show their saturation with malaria in their faces. Another marked feature

about the children is the protrusion of the abdomen due to their enlarged spleens. The lack of energy displayed by the Macedonian Greek, though probably very much the result of living in such a hot enervating climate and of having many generations of malarious ancestors, is largely due to the effect of his own particular attacks of malaria.

When a female anopheles bites any of these people, she can hardly fail to miss absorbing some of the plasmodium organisms, which she will inject into her next victims, who may be British soldiers. Fortunately, there are not many natives near the front.

Villages abound, but many of them are tenantless, having been destroyed in the various wars. The grass-overgrown ruins afford many hiding-places for hibernating mosquitoes, and for those driven in by rain and by artificial fires.

It will be seen from the above that, owing to the natural characteristics of the country and of its inhabitants, the mosquito has an easy task in transmitting malaria, while the anti-malarial worker has a correspondingly heavy one.

CHAPTER IV

ANTI-MALARIAL MEASURES: ADMINISTRATION

THE organisation that had been adopted in the area to which we were attached was very complete.

The Deputy-Director of Medical Services at the head of this organisation had a system of workers which could only fail in efficiency by individual neglect; this, if it happened, could be soon detected. The Assistant-Directors of Medical Services were responsible in their respective divisions.

Divisional areas were divided into districts, with the officer commanding a Field Ambulance responsible in each. These officers appointed malaria medical officers from their units to superintend anti-malarial work in the areas from which they collected and evacuated sick and wounded.

Beyond these were the regimental medical officers, who were responsible for their units and their battalion areas as regards malaria, and superintended the anti-malaria squads of their units when such existed.

Outside the above direct chain, but connected with it, were the sanitary sections attached to the corps and divisions, which co-operated in the work.

Beyond the divisional areas, the O.C. corps headquarters sanitary section, during the summer of 1917, acted as a special anti-malarial officer for the corps area, and was responsible for the drainage, canalisation, and other treatment of all forms of water in his district.

The A.D.M.S. (sanitary), and some experts, general, or temporarily attached, also made frequent surveys, and were available for consultative purposes.

Reports were sent in weekly by the various officers as to the nature and progress of the anti-malarial measures taken. The reports were accompanied by maps. Monthly reports were also sent in by some of the anti-malarial officers.

The question of labour for anti-malarial work was a serious one. Where possible, the regimental units had to supply the necessary men for dealing with water within a reasonable distance (generally half a mile) of their respective camps. It has been assumed that half a mile is about the limit of flight of a mosquito, but wind and other circumstances affect this limitation, and there are very many exceptions. It is not a safe rule on which to depend.

Various military requirements interfere from time to time with the use of soldiers for ordinary anti-malaria work, but it is an important duty, and may be much more valuable than some of the other drills or duties. Only the executive commanding officers can have the responsibility of deciding as to the best method of using the men in fighting areas. Many of

them have given very sympathetic help. It would be far preferable to have a permanent skilled anti-malaria squad of workers. These could be formed independently and attached for the special work.

Behind the lines, civil labour under skilled direction is an excellent method of carrying out the work. The natives can work all day, whereas the soldier, new to the climate and handicapped by other duties, can only work within limited hours. The natives, moreover, are accustomed to draining and ditching. They have to be adequately superintended to work well.

The value of natives in anti-malarial work has not been nearly enough appreciated. Applications to military authorities for native labour were received with much demur. With much pressure a squad of twelve natives was allotted in July in one area where such work as channelling was badly needed. These twelve Turks did much good work, and for one or two weeks, through persistent requests and refusals to be put off, the use of a large number of short-time local prisoners was obtained.

At the time when only twelve natives were allotted, in an urgent period of the malaria season, over twelve hundred were employed in repairing roads in the same limit of district. Prevention of malaria just then should not have been rated at one-hundredth the value of the repair of roads.

CHAPTER V

REMOVAL OF MEN FROM MALARIOUS AREAS

HISTORY has shown that there have been times when military and other operations have had to be abandoned owing to the ravages of malaria. Recent history in Panama and elsewhere has shown that the knowledge of the connection between malaria and the mosquito has ended this helpless position, where the necessary money and labour are forthcoming.

In Macedonia the malaria problem is complicated by the fact that some of the worst mosquito haunts and breeding-places lie within the fighting zone, and this limits the possible extent of anti-malarial measures. Outside the fighting zone the destruction of mosquitoes and other means of lessening malaria are matters of time, labour, and expense.

In the Struma district in 1916 the impossibility of adopting sufficient measures made it advisable to adopt another line of front. Elsewhere the military advantages outweigh the disadvantages through illness, particularly as this latter is proportionately decreasing owing to the measures taken.

Although it is necessary for the troops to remain in

this malarious country and fight on a malarious front, much illness can be prevented by care in choosing camp sites for the many troops not actually in the front line.

We think that more could be done in this direction. In choosing sites away from the front line, it is advantageous to keep a proper sense of proportion between the importance of malaria prevention and that of military convenience, as apart from military necessity.

In any case, expert medical advice should always be obtained in the anti-malaria interest, even if for military reasons it must be eventually disregarded. A *via media* may be arrived at in some such cases which may reduce the number of cases of malaria without detriment to military interests.

The neighbourhood of water, for example, is always important for camp sites, especially for those units with much animal transport. The trouble and inconvenience, however, of carrying water for some distance from a "malarious" stream to a camp, would in many instances be well repaid by a lessening of the number of cases of malaria.

As regards efficiency of the unit, the repayment through health may be very great; as regards expense, the laying in of a pump and pipes, or the carrying of water for a distance by mule labour, is obviously far cheaper than the unending cost of sick men and their attendants, and of the resulting reinforcements necessary.

We have in mind an animal transport unit where

the sickness through camping near a river-bed must have far outweighed the advantages from proximity of water. Practically all the officers and men had malaria at some time, with frequent recurrences.

Camps should be well up a hill. Mosquitoes dislike wind. If there is a prevailing wind, a site on the windward side of the water should be chosen, and as far from it as possible. The half-mile limit sometimes advised is a useful working figure, but to be varied according to circumstances, especially in the direction of an increase of distance.

Whenever possible, men should be away from the neighbourhood of water in Macedonia after sunset. In most camp areas some portions are more free from mosquitoes than are other parts. In the long summer evenings we have seen men bathing in, and sitting too near to, the water after sunset. The beauty of some of the ravine streams and the coolness of the water are temptations to running risks by remaining by them after sunset.

CHAPTER VI

DESTRUCTION OF THE ADULT INSECT

WHILE the mosquito is most easily destroyed in large quantities in its larval stage, much malaria may be prevented by the systematic destruction of the adult insect itself. As the female anopheline lays about 100 eggs at a time, the destruction of a female adult particularly is as valuable as that of many larvæ. The haunts of the insect by day are especially undergrowth, such as weeds and long grass, and places sheltered from the light.

Clearing undergrowth by cutting and burning, especially along stream-beds, is generally possible, and very much has been done in this direction. "Prairie fires" have been very extensive and useful. In some places near the "front" clearing and burning cannot be carried out. Undergrowth is often a protection from observation. The men of a unit that had a sharp bout of malaria had about a fortnight previously been engaged in putting up wire in dense grass.

Our troops do not occupy many buildings at the front, but a favourite day haunt of the mosquito is the universal "dug-out" used by the men for sun

protection or for shelter from shell-bursts. There are necessarily many of these places, of all sizes and shapes, which possess the attributes of shelter, coolness, and absence of light in various degrees. Very dark " dug-outs " in the ravines, harbour many mosquitoes.

" Prairie fires " and heavy rain tend to drive the mosquitoes into such places. Destruction of mosquitoes in buildings and " dug-outs " can be carried out by fumigation with sulphur in the proportion of 1 pound to 500 cubic feet of space. Burning of cresol is also useful. Spraying with 1 per cent. solution of formalin or other insecticide is effective. For this purpose the foot sprayer is better in practice than the knapsack sprayer. Syringing is not so useful.

Anophelines will bite in the " dug-outs " during the daytime. We have seen one biting the wrist of an officer at midday, though there was enough daylight in the " dug-out " for ordinary purposes. Anophelines hide in accumulations of such articles as clothes and bedding, and between the layers of double tents. A Greek church used for services required regular disinfection for mosquitoes shortly before each day's occupation.

In the " dug-out," the entrance of which is illustrated, by one sweep of a small net along the wall eight mosquitoes were caught. The place was thoroughly fumigated, and none were then found. Within thirty-six hours mosquitoes were as prevalent there as before. A single fumigation only deals with the insects present. The process does not prevent

others from adopting the shelter almost at once. The effect of formalin is most lasting in this respect, but ceases when it also ceases to be unpleasant to men.

The openings into "dug-outs" should be covered with mosquito-proof netting after fumigation, spraying, or otherwise clearing out the insects, and to be effective this netting should be in constant use. This applies especially to "dug-outs" used regularly as day shelters.

Individual mosquitoes may be caught and killed at twilight in rooms or "dug-outs" through their tendency to fly to the windows or nets over the openings. They can also be killed on wall surfaces during the day, especially near sunset and sunrise.

Tents and bivouac nets should be examined night and morning for mosquitoes. In cases of defective or insufficiently closed nets the mosquitoes found in the morning are often full of blood.

"Fly-papers" are of a very limited use. Placed near window openings or by the lamp, mosquitoes may be caught on them towards evening, as well as very many of the "sand-flies" which also cause a troublesome fever.

The hibernating mosquito should be specially sought out and destroyed during the winter. It will usually be found in the dark corners of unceiled roofs, cellars, outhouses, etc.

The electric torch or other light should not be brought too close to the insect if the mosquito is to be killed with a "fly-flap." Mosquitoes can also be driven

out into the cold. When possible, however, destruction is better than driving out the insects. Each building in a locality should be systematically examined about every fourteen days, starting from early in November. Double tents and " dug-outs " should also be dealt with by periodical taking down and fumigation respectively.

Articles, such as blankets and clothing, should be shaken out from time to time. We have known biting to follow the opening of bundles of clothing.

Although cases of malaria in the following spring are often instances of relapses, it is quite possible that they may be fresh infections due to mosquitoes that have hibernated.

CHAPTER VII

DESTRUCTION OF THE EGGS, LARVÆ, AND PUPÆ

THESE forms of the mosquito are more easily destroyed in quantities than are the adult insects. The problem of their destruction resolves itself into one of dealing with the open water of the district.

The anopheline wishing to lay its eggs is said to have preferences for certain conditions as regards the water it selects; clear, still, and shady waters have been mentioned in this respect. We can confidently state that for practical purposes no open water must be regarded as above suspicion. We have found anopheline larvæ in all varieties of water—in running, as well as in stagnant water; in dirty, as well as in clear water; and in water open to the sun, as well as that in shady pools. We remember two shallow pools in particular, one in a sandy bed and one in a rocky ravine, in which there was not a vestige of weed, and which were quite unshaded. Each contained very large numbers of anopheline larvæ, whose shadows were distinctly reflected on the sandy bottom of one, and the rocky bottom of the other.

In the marshy districts surrounding the lakes the

PLATE III.

A.—RUSHES AT THE LAKE MARGIN.

B.—A STREAM-BED WITH MANY WEEDY SHALLOW POOLS:
A FAVOURITE BREEDING-GROUND.

To face page 41.

extensive breeding-grounds are very difficult to deal with. In these situations the marsh is seen at its worst. There are two large lakes in the area in which we served, one of them being about forty square kilometres in extent. The marshy portion of the borders of this latter is in the front line, and so cannot be adequately drained or otherwise treated. A certain amount of oiling could, however, be carried out with advantage. The marshy area of the other lake's borders is about twelve square kilometres in extent. A main road runs along it for some miles, and it is necessary for there to be various camps in the vicinity. In the marsh around this lake the water-logged soil is full of rushes and other shorter vegetation. The rushes are eight feet high in places, and they and the undergrowth are so densely packed together that evaporation is almost nil. There are some patches of open water in this area. Nothing short of a large and costly scheme could render this marsh free from the mosquitoes which abound there.

If this district must still be occupied by the army to such an extent as it was in the summer of 1917, we think that the problem of improving the state of the lake border should, however, receive considerable attention. The men of the units who had to live near, and work along, the adjoining road suffered very considerably from malaria.

It is to be feared that the magnitude of the work, the expense, and the difficulty of getting labour are prohibitive as regards this swamp; but we think

something of considerable effect might be done in the direction of reducing the amount of vegetation, and by oiling parts adjoining the shore where the larvæ are mostly found. At least, numbers of the pest might be destroyed, and it is here that a mosquito was found apparently associated with a bad form of malaria in adjoining units.

In the open water of the lakes the larvæ have not such favourable circumstances for development, since the movement of the water owing to wind is injurious to them. Drowned mosquitoes can be seen to the leeward side of large water surfaces still entangled in their pupa cases.

RIVERS.—Fortunately, it is only in the case of the large lake marshes that destruction of larvæ presents what has hitherto been considered insuperable difficulties. Elsewhere, though many, the difficulties can be, and have been to a great extent, overcome. In the many valleys and deep ravines due to the hilly nature of most of the occupied area the flow of water is fairly fast except in the height of the dry season. In the plains the flow in the streams formed from ravine water is more sluggish. The stream-beds of the latter especially, being large enough to take the winter water, are partly empty in summer, and contain as a rule a small, slowly flowing, often intermittent, stream with many adjacent pools. All the streams have irregular overgrown edges with weedy semi-stagnant offshoots in which larvæ flourish.

Channelling, and filling in of pools, are therefore the

PLATE IV.

A.—A WIDE STREAM-BED WITH MANY POOLS. ANOPHELES IN LARGE QUANTITIES.

B.—THE SAME STREAM-BED LATER. THE NARROW CHANNEL HAS DRAINED THE SHALLOWS, AND THERE WERE NO LARVÆ.

PLATE V.

A.—A SMALL STREAM IN A RAVINE BEFORE TREATMENT. MANY LARVÆ PRESENT.

B.—THE SAME STREAM CHANNELLED AND CLEARED OF WEED. NO LARVÆ

To face page 43.

principal works necessary in the beds of streams. The water should be confined to a space, in width, only just large enough to contain it without overflowing. As regards depth, there must be borne in mind the tendency for a channel to soon fill up with silting mud and sand.

The channelling should, as a rule, be in the direction of the natural course of the stream, otherwise overflows will occur when silting begins. The banks of the channel should be made as strong as possible, for animals are liable to break them down. Stones are useful for strengthening these edges. The channel itself should be cleared of weed. In places where a stream has been flowing quite quickly we have found larvæ and pupæ among the weeds. The species of fine green weed most commonly met with in these situations is easily cleared, and if thrown out on to a dry surface the larvæ in it rapidly die.

The channel banks must be sharply cut. Any small bay or indentation in their sides encourages stagnation, weed growth, and breeding of larvæ.

A rocky bed is difficult to treat by channelling, but the difficulties can be overcome if the general principles of a swift stream with sharply cut edges and free from weeds, are borne in mind.

The formed channel is better left open than covered with stones, as is sometimes done, except where a bridge is necessary. Defects and weeds must not be hidden from the periodical patrols.

In each stream-bed, ponds and pools are to be found,

sometimes connected with the stream, sometimes isolated. They are generally full of weeds, and are favourite breeding-grounds.

Occasionally they can be drained dry by a channel into the main stream. Oftener the bottom of these pools is at a lower level than the water in the stream. Filling in to above the water-level with earth or sand, is the best treatment for pools that cannot be quite emptied by drainage. The material used should reach a height that will prevent a hoof-mark from forming a little pool. A permanently dry surface is also necessary from the fact that anopheline larvæ can exist in very wet sand or mud.

In the instances where draining and filling in are not possible, oiling may be done. Crude petroleum or other oil that will make a fairly stable surface film will quickly destroy larvæ. Half a pint of petroleum will make a film over about 100 square feet of surface. It should be applied by a sprayer. Failing a sprayer, a sack can be soaked in oil, weighted by a stone, and thrown into the centre of the pond. The oil can also be applied by slow dripping from a tin with a tiny aperture. This method is useful for automatic re-application in slowly moving water, or at the windward edge of a pond. Theoretically, once a week should be enough for re-oiling, but practically oiling is not a success unless it is done about three times weekly.

The drawbacks to the use of oil include the items that wind clears the oil from windward to leeward, that rushes and weeds interfere with the essential

PLATE VI.

A.—A WELL-CHANNELLED STREAM-BED WITH ONE POOL LEFT NEGLECTED AND FULL OF LARVÆ, THOUGH OPEN TO THE SUN AND WEEDLESS.

B.—A SIMILAR NEGLECTED POOL UNDER A BUSH, ALSO FULL OF LARVÆ.

To face page 44.

PLATE VII.

A.—PROCESS OF CLEARING A STREAM NEAR A CAMP OF MOSQUITOES AND LARVÆ; THE UNDERGROWTH PARTLY CLEARED AWAY.

B.—CHANNELLING THE STREAM BY NATIVE TURK LABOUR.

To face page 45.

continuity of the oil film, and that the water may be wanted for watering animals, or for bathing and washing purposes.

Subject to these drawbacks, and remembering that constant attention is necessary, oiling is useful where draining and filling in cannot be carried out. All ponds should have clean-cut edges, and be cleared of vegetation regularly.

Ponds in the course of streams, when deepened by the aid of a dam, are often used as bathing-places. All bathing-ponds should have a sluice in the dam by which they can be emptied at least once weekly. If the water is not used lower down, it might with advantage be oil-sprayed the night before emptying. It is better to destroy larvæ than to pass them on to neighbouring areas.

After the flushing, water from it may collect in temporary ponds lower down, and may remain stagnant long enough for mosquito breeding. This fact should be remembered, and examination made accordingly.

Swamps.—In addition to the marshes mentioned in connection with the large lakes, there are two special varieties of swamp that require attention. From the nature of the ground, a stream or waste may flow into an area from which there is no natural outlet. These areas have been successfully treated by channelling as far as possible, and by then cutting a large pool or series of pools with sharp edges and free from weeds which can be regularly oiled.

The other variety of swamp is caused by the rising

of a spring in a level piece of ground, which is water-logged up to the point where a natural outlet is found. A channel should be cut from this outlet as far as possible into the swamp in the hope of getting near the rising-point of the spring. The channel should be deep enough to drain the surface area in the immediate vicinity.

In the district there is a large swamp, or rather pond, fed by underground springs or mountain drainage, and full of rushes and other growth. This pond was a fertile source of mosquitoes. It is situated high in the hills in a saucer-like depression in the rock, and could not be drained by a channel without much blasting of rock, and was too large to be filled in. It was, moreover, within long range of the enemy's guns. A six-inch iron pipe siphon was fixed, and reduced the depth of water by four feet. Thus the surface area of water was very considerably lessened.

Trenches with clean-cut edges will often collect the water of some swamps, which can then be oiled or otherwise treated. From all varieties of water rushes and weeds should be cleared, and the undergrowth along the banks, which harbours mosquitoes, should be cut away and burnt.

ACCIDENTAL WATER.—In addition to the above forms of water accumulation, there are various small but fruitful mosquito breeding-places which are more dangerous than they seem to be at first sight. Many of them are found close to human habitations, temporary or more or less permanent, and consequently

PLATE VIII.

A.—SIPHONING A LARGE POND IN A CUP-LIKE DEPRESSION AMONG THE HILLS.

B.—A HAUNT OF HIBERNATING MOSQUITOES IN A VILLAGE DESERTED EXCEPT BY STORKS AND INSECTS.

To face page 46.

PLATE IX.

A – A "DUG-OUT" IN A RAVINE. A FAVOURITE ANOPHELINE HAUNT.

B.—A VILLAGE FOUNTAIN WITH MANY LARVÆ IN THE WASTE WATER.

To face page 47.

the mosquito is near its desired source of human blood.

There are very numerous native water fountains throughout the occupied area. We have often found anopheline larvæ in the overflow waste water from these. This waste water forms a marshy piece of ground which requires canalisation. The canal or channel should lead into a stream, if possible; otherwise it should be led into a large pond or pit that can be carefully examined and treated from time to time.

We have found abundant anopheline larvæ in a neglected tub or half-barrel containing water at a drinking-supply tap fixed on a pipe in a ravine. The barrel was used to rinse vessels and to catch waste, and was never thoroughly emptied. The men of the adjoining infantry unit regularly visited this fountain for water many times daily, and, worse still, in the evenings. Malaria cases were occurring among them.

Finding larvæ in hoof-marks along the edges of streams, has been our constant experience. These accidental holes should be at once filled in.

Two neglected tubs in a vegetable-garden were found to contain many larvæ, in a district otherwise comparatively free from anophelines. Water was often put into these tubs, but they were never completely emptied. A fortnight after the removal of these tubs some otherwise unaccountable malaria in a neighbouring unit abated.

Any neglected tin or vessel with its opening upwards, and capable of containing water for over a

week, is a possible source of danger. There are many such tins in an army area. Abandoned horse-troughs may also become breeding-places.

Irrigation channels in cultivated gardens must be carefully watched. A clay soil may cause water to stagnate long enough for the mosquito to make use of it.

It is useful to place in suitable situations some vessels containing water in which the mosquito can lay her eggs, if there is no chance of neglect to attend to them. We have used the easily obtained petrol tins for this purpose, in places and circumstances suitable for the mosquito. A curious fact about these traps is that, no matter how artistically the tins were dug into a bank, so that weeds and growing rushes were overhanging the water, we have only so far been able to attract to them the culex mosquito, although anopheles have been breeding in water close by. Such traps are of a double value. By regularly killing the larvæ at least once every week the development of a large number of mosquitoes can be prevented. They also give some indication of the presence and species of mosquitoes in a neighbourhood where, as has been the case in the experience of others, anophelines have also been persuaded to use them. Incidentally, the trap is of value in demonstration to the sceptic, and for instruction.

PATROLLING.—In the foregoing account of anti-larval measures it will have been noted that there is a paramount necessity for constant "patrolling," even

if the structural work has been well done. The water within the radius of at least half a mile of any camp should be inspected twice a week by some responsible person of the unit. This is the duty, as a rule, of the medical officer, who often has a " sanitary " N.C.O. or private at his disposal.

The individual patrolling should note and pay attention to the following:

(*a*) Repair of the channelling, which is often broken down by mules, natives, or otherwise. It may also have become ineffective through silting up and after a heavy shower.

(*b*) Accidental pools; the obliteration of hoof-marks.

(*c*) Removal of weeds from streams and pools. Re-making of sharp banks.

(*d*) Re-oiling of pools thrice weekly, especially if larvæ are found there.

(*e*) Clearing out and opening the sluices of bathing-pools.

(*f*) Empty vessels found about the area. These should be emptied of water, and holed, flattened out, or placed bottom up.

(*g*) Clearance of waste flows, irrigation water, water in tubs, and waste water at fountains.

(*h*) Mosquito traps.

Maps and plans of the work done should be prepared weekly.

Suggestions as to the use of mineral poisons in the water cannot be entertained, owing to the number of men and animals that might be endangered.

The cultivation of fish might be useful to some extent, but we have continually found numbers of small fish and anopheline larvæ living apparently amicably in the same pond.

Natural enemies of mosquito larvæ probably exist, but do not make such an impression on their numbers in Macedonian waters, as would warrant any neglect of other methods of destruction.

PLATE X.

A.—A WELL-CHANNELLED RAVINE STREAM, WITH STONES TO PROTECT THE BANKS. NO LARVÆ.

B.—A RAVINE OF ROCKS. THE SLOWLY FLOWING STREAM CONTAINED LARVÆ.

To face page 50.

CHAPTER VIII

PROTECTION OF THE MEN FROM BITES

It is obvious that during the course of a military campaign in such a malarious country, the whole area occupied by troops cannot be rendered free from mosquitoes and their larvæ, in the time and by the means at disposal. It is of the utmost importance, therefore, that efficient measures should be adopted and properly carried out for protecting men from being bitten.

First among these measures is the use of nets at night-time. To keep out mosquitoes, the mesh of the netting fabric must be of at least twelve openings to the inch, and a finer mesh of eighteen openings is preferable.

It is not necessary to describe in full detail the construction of the nets used, especially as experience has led to frequent improvements. The important fact is that in 1917 some form of net, quite efficient if properly used, was universally provided.

The " bivouac " net has been the ordinary form. Two men sleep under each net. The illustration shows the arrangement. The net is covered on the top by

a movable bivouac waterproof sheet, and is sometimes under a sun shelter. If it is kept in repair, and the simple instructions with regard to its pitching and closing at night are carried out, it is quite efficient for its purpose. Its handy size and light weight are important where mobility is so essential and transport facilities are so limited.

A disadvantage of this " bivouac " net is its frailty. Strengthening bands of material should be added to its large surfaces. Another drawback is that the net is low. There is thus insufficient space, especially head-room, and consequently men use such expedients as that of raising the poles on stones. Openings are in this way left for mosquitoes to pass through, and the net may become a trap instead of a protection. The best method of meeting the difficulty of head room is to hollow out the ground in the interior for about one foot in depth.

Improved " bivouacs " are being devised as a result of this year's experience. There will be more room, and they will be more " fool proof " as regards the closing-up arrangement.

Failure of efficiency with regard to the net is due to ignorance or neglect of the occupants, who from fatigue caused by heat or work, or in some cases from laziness, do not close the net properly at night. The neglect of the occupants in not repairing accidental holes also leads to inefficient protection.

On one occasion a surprise visit was made at night to a small unit, and we found only three out of twenty-

PLATE XI.

A.—THE USUAL BIVOUAC FOR TWO MEN WITH MOSQUITO NET.

B.—A MOSQUITO-PROOF HUT.

To face page 52.

six nets properly closed, although cases of malaria were of daily occurrence in this unit. A few minutes must be occupied in closing the net properly, but they are essential, and the trouble is well repaid.

The night nets, of any form, should be in place and closed from mosquitoes at sunset. After fixing, it is well to make sure that no mosquitoes have accidentally been shut in.

Simple as the closing process is, systematic drill should take place after the trial instruction has been given. The nets should be examined as to proper closure after turning-in time by someone responsible and able to insist on immediate closure.

Repairs should not be left to the men themselves, as is usually the case, but one or more men who can use the needle should be detailed for that special duty. A net with a hole may become a mosquito trap.

Another form of net issued to the troops this year was shaped so as to fit inside a bell-tent. There is more room in nets of this pattern, but they possess no special advantages over the " bivouac " nets in efficiency against mosquitoes.

Neglect to properly close the openings is common. We have found the nets of a row of seven occupied tents all open at night, and have also frequently found large holes in the nets. If mosquitoes get in they are less easily caught than in " bivouacs." In many camps bell-tents cannot be used. In bad weather this form of protection is preferable to that of " bivouacs," but this was negligible, in that almost

no rain fell in the district during July, August, and September, 1917.

Special mosquito-proof huts with wire netting of fine mesh have been used in certain parts during the latter part of this summer. They proved very successful, and might be used with advantage on a more extended scale next year. An illustration of one such hut is given. There is much space in them, and more protection from the elements.

Wire netting and fine fabric mesh have been much used in door and window frames for protecting huts and " dug-outs." This protection is not very reliable, and needs frequent attention. Wood warps readily in the hot sun, and the edges of " dug-out " openings are often very irregular and crumbling.

The ordinary mosquito net, used over a bed, with the edges tucked in, can only be used in favourable circumstances.

All forms of net require nightly supervision and protection. A mosquito can easily bite a bare skin surface which is pressed against the net.

An important point in connection with the proper use of nets is the fact that there are now so many malaria " carriers " amongst the troops. It is essential to efficiently shield these men from bites, not merely to protect themselves from re-infection, but also to avoid the transmission of infection from them to others.

Night nets should be used as long as mosquitoes are prevalent. Fixed dates for their commencement

PLATE XII.

PROTECTION VEIL, GLOVES, AND "SHORTS" TURNED DOWN OVER THE BARE KNEE.

To face page 55.

and discontinuance are less important than the circumstances of the year. Anophelines were still biting in November, 1917.

FACE NETS.—For men who have to work at night it is very necessary that the uncovered portions of the body should be protected in some way. Veils that fit on to the cap or helmet are provided. They have each a stiff metal ring midway, to keep the material from settling on the ears and nose.

These nets must be properly put on. We have seen men using the veil with the ring on the cap, and the veil thus touching the nose, ears, and chin when the end was tucked into the collar-band. Unprotected skin surface was thus at the mercy of the mosquito.

Certain work cannot be done under veils, especially at the front.

Gloves are also provided for night work. The wrist of the glove is not, as a rule, long enough, unless the man has his sleeves well pulled down. Experience has led to fool-proof improvements in the detail of the veils and gloves, if required for another malaria season.

"Shorts" are universally worn in summer, leaving much of the knee and thigh bare. The "shorts" now provided have an extension which is turned up in the daytime, and can be turned down over the bare parts at night. In the illustration the leg of the "shorts" is turned down on one side. There is, we understand, an order as to turning them down at sunset. If so, this order is too frequently disregarded. It seemed to

be nobody's business to insist on this precaution being taken, and the men seemed to object to the appearance of the turned-down "shorts."

In connection with face nets, the following experience that is fortunately not common may be cited: For certain purposes it was found necessary to form a camp near the bed of a stream of a bad type—*i.e.*, a sandy river-bed about thirty yards wide, with a sluggish stream about one yard wide, spreading into pools. Anopheline larvæ were very plentiful here, and steps were at once taken to deal with the stream and pools. We found that no face nets had been issued for the night guard. This deficiency was immediately reported.

Four days later, on visiting the camp, we found that this report had just reached the commanding officer of the unit after passing through the hands of three departmental chiefs. The C.O. was requested by the last of these to indent for the veils. He did so, and the veils arrived after about two to three weeks. Eleven cases of malaria occurred, after the lapse of twelve days from arrival in this camp, before the veils arrived. Five of the affected men had been on night duty.

It ought to be in the power of the medical chief to send these nets at once when necessary. The medical department has too little executive power in such matters.

Repellents.—It will be understood that there are certain military duties to be performed at night, which

preclude the use of any form of face net. Some ingenuity has therefore been exercised to find a material that, being applied to the skin surfaces, will repel mosquitoes. Substances that have had, at some time, something said in their favour in this respect, by the troops using them in Macedonia, include the following:

Crude paraffin.

Paraquit (official issue).

Strong essential oils rubbed up in a base, such as vaseline.

Tar preparations.

Vermijelli.

The verdicts of the men using these preparations have varied considerably from "quite successful" to "the mosquito seems to prefer those with the preparation on."

Our own personal experience is that there is a short period during which these preparations repel mosquitoes, and that this is the period during which the odour is strong.

Oil of citronella kept off biting insects for half an hour. After that period the oiled skin exercised no repellent effect.

There is no doubt that, on the whole, repellents of the above kind are useful for a time, and the first two of them seem to us to have the best effect.

Without depending on them when the previously described precautions are available, they must, be considered useful to those who, from the nature of their duties, have exposed skin surfaces at night. Repeated

applications of the preparation must take place, especially if there is much perspiration.

From practical experience we have noted that men are careless in the matter of malaria prevention, despite the numbers of sick they see around them. The men are too often in the ravines and near water-courses in the evening. By sunset all men should have left water-courses, bathing-pools, and ravines, except those whose duty compels them to be there. We have seen men bathing in the streams after sunset in August. This was, of course, stopped when reported.

Ignorance should be more combated. There should be systematic drill in anti-malarial measures. The French have issued instructive and amusing posters and picture postcards on the subject. We have interested many men by showing them the larvæ, and explaining how the mosquito develops and how it spreads disease. This might be done systematically.

In this connection we may refer to the fact that two newly arrived medical officers told us that attendance at the lectures on malaria in their recent home R.A.M.C. training was optional!

Where "dug-outs" are used for shade during the day more attention should be given to killing the mosquitoes in them, or to driving them out. The "dug-out," if unprotected by a net, should be abandoned, if possible, before twilight.

CHAPTER IX

QUININE PROPHYLAXIS

WHILE the efficacy of quinine in the treatment of malaria is so very marked, its value as a prophylactic is a subject on which expert opinion has been varied and contradictory. From our experience in Macedonia we may say at once and emphatically that the prophylactic value of quinine in the doses given, has been at all events so incomplete and questionable, that none of the other precautions can for a moment be neglected in favour of such practice, however universally it may be carried out.

Previous experience of the ravages of malaria resulted in a practically universal adoption of the taking of quinine as a prophylactic in our area during the summer of 1917. Notwithstanding this, malaria has occurred in the case of a very large proportion of the men. In some specially exposed units very few of the men escaped one or more attacks.

Men receiving at least 10 grains of the sulphate in solution twice a week, and often up to 10 grains daily, for a long period, have been taken ill with malaria, primary and recurrent. We may go so far as to say

that in the summer of 1917 practically all the malaria patients had been taking quinine as a prophylactic in these doses. This confirms the results of experimental investigations with small doses in other countries.

If it were possible or advisable to give curative doses of 30 grains daily as a prophylactic, instead of the doses mentioned above, the effect would have perhaps been more marked; and if other precautions are impossible, or nearly so, men might be protected in this way. It is likely that the doses that have been given have lessened the number and severity of the attacks, and have enabled more men to remain on duty, though we can give no figures to bear this out.

Thorough attention to the other anti-malaria precautions would make the taking of prophylactic quinine unnecessary, but this thoroughness is not always practicable owing to military exigencies.

The broad facts are sufficient for practical purposes. They indicate that, while quinine prophylaxis should still be employed, especially where other precautions are difficult, reliance should be placed infinitely more on the various methods of protecting men from the bite of the mosquito.

We have found that there is occasionally a danger from an excessive faith in quinine. In some instances this has led to a lessened activity in the more arduous directions of prophylaxis, such as proper attention to adjacent water and to keeping "bivouac" nets repaired and properly closed at night.

In the early days of the Macedonian campaign men often evaded their quinine by not being present at the parade, by being away from the centre of the unit, by ejecting the quinine from the mouth, and by other methods. Direct refusals to take it were uncommon. To make more certain of administration, the medicine had to be given in solution, and sometimes the device was necessary of making men swallow after taking it by requiring them to at once mention aloud their respective regimental numbers.

Personal experience of malaria and its effects, and the desire to avoid them, has reduced to an almost vanishing-point any serious wish amongst the men to neglect their prophylactic dosage, though they do not like it.

Of the powder, tablet, and solution forms of administration, the last is the most certain. The small amount of inconvenience is more than compensated for by the certainty of the man getting his dose, and that it will not pass unchanged through the intestine, as might happen with a tablet. It should be given after a meal, and in the evening.

A method of administration generally adopted in 1917 was as follows: Every man had a dose of 10 grains of the sulphate of quinine in solution on Thursdays and Sundays, old malaria patients an extra two doses of 10 grains each per week, and men in very malarial areas at the front, where other precautions can only be partially, if at all, observed, 10 grains per day.

The question has been sometimes asked: Is the

efficiency of the men affected by prolonged dosing with quinine? The question is a difficult one, and has received, and is receiving, attention by experts.

On the whole, the answer to this question is apparently in the negative. Cases of cinchonism with the doses mentioned were very rare; gastritis, sufficiently marked to be reported, was not at all common. We noticed a certain amount of deafness, and occasionally a slight slowing of mental effort. The hard work of the front-line troops in Macedonia has, however, gone on as usual, in spite of the effects of malaria and the hot, moist climate.

An intelligent and tactful medical officer of a unit could easily deal with any idiosyncrasy to quinine as it arose, without interfering with routine administration.

An important feature of quinine prophylaxis is that in curative doses of 30 grains daily the drug might have a good effect in reducing the quantity of infective material by destroying the organism in the blood of carriers. It has been proved that in small doses. quinine has not much, if any, destructive effect on the sexual forms of the organism, and these are the forms that enable the mosquito to carry on the cycle of infection.

Large doses cannot be given indiscriminately until more definite information is obtained as to the possible effects of so much quinine on the constitution of the healthy individual, and on his capacity for work. Investigations are going on which seem likely to

dissipate the doubt we have at present as to the advisability of giving such large doses to men in arduous work.

Apparently, quinine prophylaxis does not interfere with the use of the drug as a curative agent, when the subject has an attack of malaria.

Quinine prophylaxis, as at present carried out, is, from a practical point of view, a form of malaria prevention that can only be considered an unsatisfactory refuge for those destitute of the other better forms.

It is well to bear in mind that, while kept up to the extent indicated, during the summer of 1917, the men taking the quinine had malaria in all forms to a very serious degree.

CHAPTER X

CONCLUSIONS

It is evident, from the foregoing pages, that the anti-malaria work of 1917 in this area has been very extensive, and it was successful in limiting malaria among the troops.

Military exigencies are such that it is inevitable that there must be exposure to infection, and consequent malaria, to some degree; under the circumstances, all the breeding-grounds cannot be thoroughly dealt with, nor can the men carry on all their night duties under nets or be always using precautions.

While the above is true, it is but natural that experience has shown that even more thorough and successful work can be carried out, if Macedonia has to be occupied during another summer.

In addition to points alluded to in the earlier pages, we venture to make the following comments and suggestions, some of which are already receiving attention to a limited extent.

Education of officers and men of all branches of the local army, as to the causes and prevention of malaria, might with much advantage be considerably extended.

Co-operation in anti-malaria measures is far more satisfactory when its basis is intellectual. Illustrated posters and postcards are in use in the French Army. Practical demonstrations of larvæ and interesting accounts of the spread of the disease by the mosquito would lead, we believe, to more practical assistance from the units in exposed positions.

A still closer co-operation is advisable between executive officers and medical officers expert in malaria, as to camp sites, where these have not to be fixed by purely military exigencies. The prevention of cases of malaria may be a substantial gain in return for some inconvenience. It is also possible that some twilight parades, at night or morning, might with advantage, and without military detriment, be abandoned or minimised.

A regular drill in net-closing and in the use of other anti-malaria measures might be instituted. That this is necessary is shown by the constancy with which torn and ineffectually closed nets are found. The use of the gas mask has to be taught by drill, and the proportion of men "gassed" in Macedonia, to that of men invalided by malaria, is absurdly insignificant.

The medical department should be able to supply right away, such items as nets and veils. The requisite forms could be filled in afterwards. The medical department in the army has too little executive power in such respects. Mere "recommendations" lead to delay, and much unnecessary waste of time and paper.

The "sanitary" men of units, who have to look after

"patrol" and other anti-malaria work, should be the best men available, and not, as is sometimes the case, chance men, perhaps unfit for other duties. On the surface their incompetency may not be so noticeable as it would be in the case of other duties, but in Macedonia particularly, special ability and trustworthiness in these men is essential. All these men should have been taught, and should have been examined in, the practical points as to malaria and its prevention.

Canalisation and similar work should be begun earlier in the year, even in March or April. This must depend to some extent on the rains, which destroy such work, but a lot can be done as the waters subside, with outlying accumulations. It should be borne in mind that, though in 1917 the very extensive biting began early in June, there were many primary malaria cases in the earlier months of the year. After a warm spell, larvæ will be found. If these early mosquitoes are destroyed, obviously a useful work will have been accomplished.

The hibernating mosquito should receive special attention in the winter and spring months. Early in November in two days a few intelligent men, specially put on for the duty, secured over 3,000 female anophelines in and near two camps adjoining two villages. In the camps themselves the average number caught in each tent between the double layers of canvas was five, and in the darkened "dug-outs" they were caught by scores. They can be caught in such shelters especially after rain. "Dug-outs" require almost daily attention.

Civil labour should be used to a greater extent where politically possible. If and where such labour is not available, then definite anti-malaria contingents might be formed from labour battalions. The anti-malaria work is as essential in Macedonia as the repair of roads, and the labour for it should be organised just as much as that for road-making and other purposes. In this way skilled workers would be eventually permanently available. It is hardly fair to put this labour on to front-line units. Even if there is time or opportunity for it to be so carried on, such labour is not regular or skilled.

Finally, we consider that insufficient notice is too often taken of lapses of care on the part of individuals in protecting themselves and others from exposure to needless risks of mosquito bites. The discovery of such items as faulty nets or neglected water-courses should involve serious consequences to the offender as surely as any important " military " offence would do. The photograph showing a bell-shaped mosquito net in a tent was not taken purposely to show the hole converting it into a trap. It is, unfortunately, an only too common sight, and its conspicuous position in this case shows how little notice is taken of such neglect.

The instance has already been mentioned of a night visit to a camp where it was found that only six per cent. of the men had taken the trouble to close their nets properly. The only censure in the case, of which we heard, was apportioned to the officer who

made the discovery for not properly notifying his visit before examining the nets of the unit.

There is no possible doubt that individual neglect of the simple precautions at hand has accounted for very many cases of malaria, and such neglect should not be treated so lightly as it is, in many cases, in such a malarious country as Macedonia.

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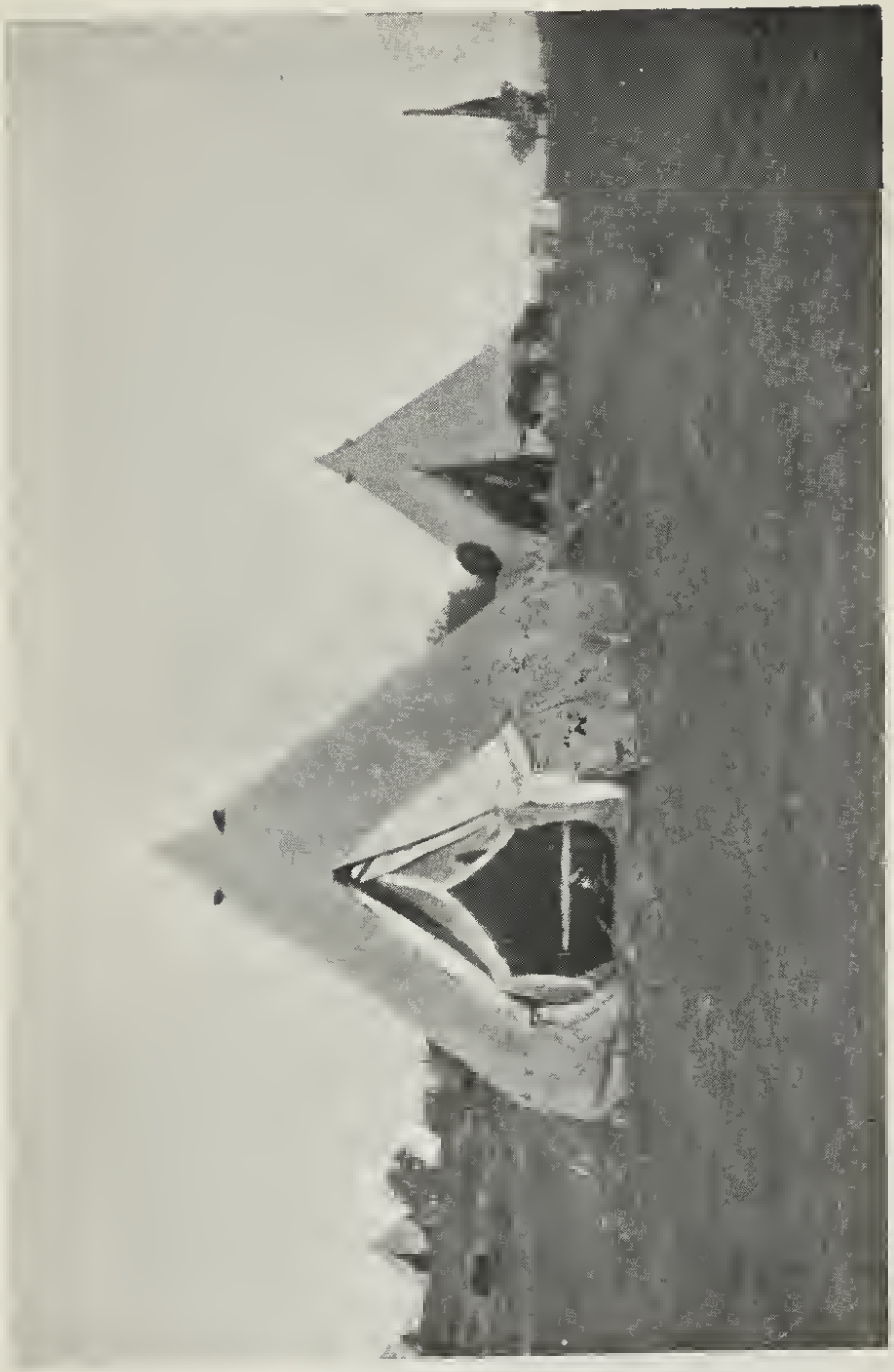
PLATE XIII.



BELL-TENT WITH A NEGLECTED HOLE IN THE MOSQUITO NET.

To face page 68.